

The Immature Stages of Six California *Catocala* (Lepidoptera: Noctuidae)

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Abstract. The traits of the ova, first instar larvae, second instar larvae, and fifth instar larvae that are shared by *Catocala andromache*, *C. benjamini*, *C. californiensis*, *C. chelidonia*, *C. johnsoniana* and *C. mcdunnoughi* are summarized. The ova and larvae of the six species are described. Keys for the separation of the first, second and fifth instar larvae are provided. The larvae are oak feeders.

Introduction

The early stages of six species of small California *Catocala* have not previously been published. The species are *Catocala andromache* Henry Edwards (1885), *C. benjamini* Brower (1937, 1982), *C. californiensis* Brower (1976), *C. chelidonia* Grote (1881), *C. johnsoniana* Brower (1976) and *C. mcdunnoughi* Brower (1937). In 1978 and 1979 I reared all six species from ova, and herein describe their life histories, provide keys to the immatures, and discuss the phyletic affinities of the species to each other.

Morphological Characters Common to all Six Species

Ova: In all species spheroidal, yellow or yellow-brown, with thin, flexible choria. Micropylar areas flattened, smooth, wide. From their edges descend 50 to 75 narrow, low, rounded, smooth ribs, these dividing initially or below, reuniting or joining an adjacent rib, disappearing basally. The micropylar ends of the ribs form low, polygonal rims around the micropyle. Ova diameters: from 1.02 mm to 1.29 mm (means).

Larvae: I use the terminology of Snodgrass (1928, 1935), Hinton (1946) and Hasenfuss (1963), in describing the larvae (schematic given in Figure 1).

First instar larva: (Figure 2) Significant features: head unicolorous, brown or black with black setae; cervical sclerites matching head. Body in pale colors, setae black, strong; from prominent, brown or black bases. Ventral setae short, white. Pattern in brown to black, and except in *C. mcdunnoughi*, browns darkening to black during the instar. In all species, three longitudinal lines on upper sides, their positions constant in relation to primary setae. Line 1, uppermost, from T1, through D2 setae of TII and TIII, and D1 and D2 setae of A1 to A8, on A9 passing dorsad of seta D1 to seta D2, ending, or to A10. Line 2, from T1, through SD2 setae of TII and TIII, through seta SD1 of A1, dorsad of SD1 setae on A2 to A9, to A10, on

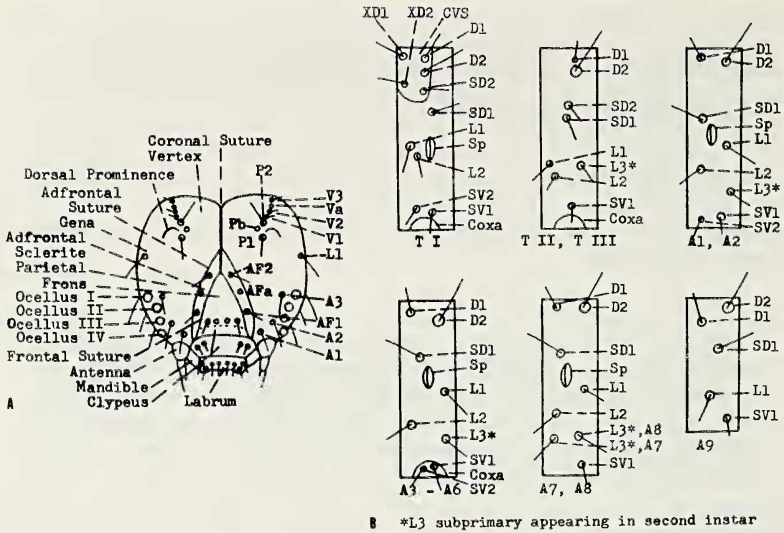


Fig. 1. **A.** Head regions, sutures, setae, and sensoria of *Catocala* larvae, dorso-frontal view. Setae with capital letters and arabic numerals; sensoria with capital letters and small letters; ocelli with Roman numerals. Only those referred to in the descriptions are designated. From reared *Catocala chelidonia* and *C. johnsoniana* larvae. **B.** Thoracic and abdominal setae of *Catocala chelidonia* and *johnsoniana* larvae. Only setae referred to in descriptions are shown. Segment 10 omitted. Head: A - anterodorsal, AF - adfrontal, P - posterodorsal, V - vertex, L - lateral. Body: CVS - cervical sclerite, XD - anterior dorsal tactile setae of T I, D - dorsal, SD - subdorsal, L - lateral, SV - subventral, Sp - spiracle, T I, T II, T III - thorax; A1-A9-abdomen.

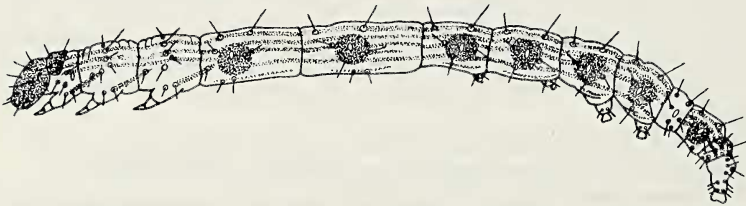


Fig. 2. First instar larva of *Catocala benjamini*, in lateral view, length about 9.5 mm.

A9 often through seta D1. Line 3, from T I, near, or through SD1 setae of T II and T III, and through SD1 setae of A2 to A9, to A10, or to anal leg. More ventrad, horizontal dashes at lateral and subventral setae, or, on thorax, oblique dashes rising dorsad and caudad from SV1 setae, to L1 setae of following segments and L2

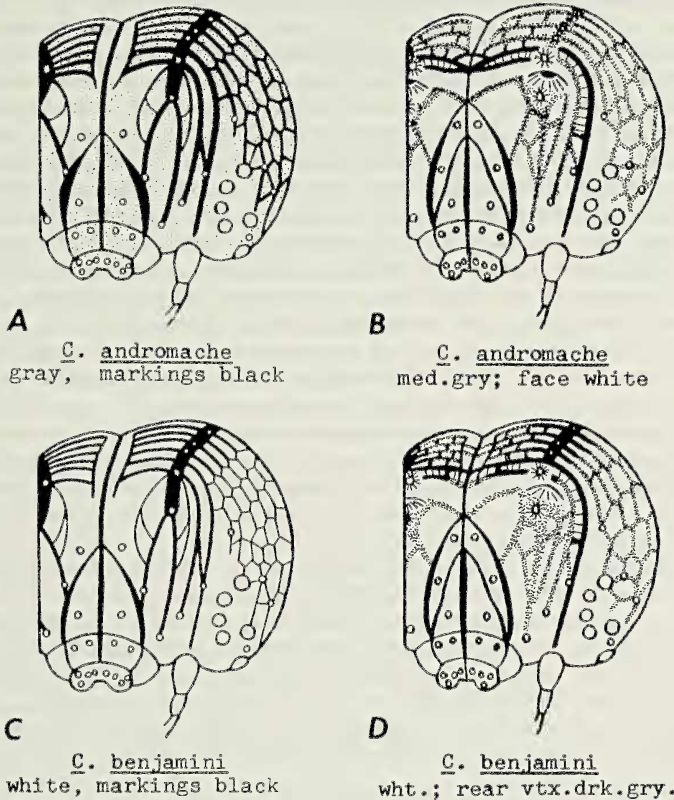


Fig. 3. Schemata of the head patterns of: **A.** *Catocala andromache* second instar; **B.** same, fifth instar; **C.** *Catocala benjamini* second instar; **D.** same, fifth instar. Small circles, setal bases; large circles, ocelli. On fifth instar heads: stippled lines, gray; solid black, black; hatching between the lines of the facial rim, and rays around setal bases and prominence above seta P1, orange.

seta of A1. On sides of A1 to A6, to A8, or to A9, large patches enclosing spiracles, and sometimes adjacent setae. Leg tarsi white, brown or black; prolegs and anal legs often accented or striped. Venter pale, median spots brown or black, large on A1 to A4, reduced cephalad and caudad. The body tinted by ingested food after feeding.

The first instar larval traits of these six species of oak feeders agree with those of the first instar larvae of *C. ilia zoe* Behr, *aholibah* Stkr., *verrilliana beutenmulleri* B. & McC., *ophelia* Hy. Edw. and *delilah desdemona* Hy. Edw., all western oak feeders (Barnes and McDounough, 1913). The eleven species, in the first instar, have brown or black heads with black setae; bodies with long, black setae from prominent, dark bases, with three to five longitudinal, brown or black lines, and with dark patches on the sides of four or more abdominal segments.

Second instar larvae: (Figures 3A, 3C, 5A, 5C, 7A, 7C) Head colors in pale shades, setae black, or upper setae black, lower setae white. The head displays a pattern definitive for the six species, the pattern continuing into the final instar. Patterns black in the second instar, for all species other than *C. mcdunnoughi*. In *mcdunnoughi* the pattern is brown and incomplete, reaching full development in the final instar. Head pattern distinctive features are: black dorsal bars from P1 setae, through P2 setae, across vertex to the caudal margin. At sides of coronal suture, narrow lines diverging caudad. From these, sets of about six parallel lines cross the vertex and dorsal bars transversely, descending in parallel briefly, forming a genal reticulum below. In *C. chelidonia* and *mcdunnoughi* the lines remain sub-parallel to lower genae, and forward to ocelli. The two most anterior transverse lines descend anterior to ocelli, forming a double rim around front. Line 1, most anterior, descends to seta A2, sometimes forking, the lateral fork joining line 2 at seta A3. Line 2, more heavily marked, descends through seta A3 to antennal base. On the front, inverted Vs, their vertices at P1 setae, the mesal arms descending to, or near, setae AF1, the lateral arms descending to setae A1.

With one exception, body patterns resemble those of the first instar larvae. The three longitudinal lines may be supplemented with additional lines, to five or six. Spiracles yellow, with black rings, in all species. In most, segments A7, A8 and A9 have transverse dorsal ridges between the D2 setae, the setal bases enlarged and conical, ridge and setae largest on A8.

Fifth instar larvae: (Figures 3B, 3D, 5B, 5D, 7B, 7D) Features of fifth instar heads: face, perioral areas and mandibles white. Most pattern lines stippled in shades of gray, few lines in solid black. Dorsal bars from setae P2, narrow, sinuous, gray (but black in *C. benjamini*). Line 1, of frontal rim, gray or black dorsally, gray laterally. Line 2, gray in two species, heavily black in four. In these four, vivid orange fills between lines 1 and 2 dorsally and upper laterally. More posterior transverse lines on the vertex, narrow, sinuous, gray, interconnected. Genae reticulate in four species, in two species, parallel-lined below. In all species, pattern lines more interconnected, and detail variable between individual larvae in *C. chelidonia* and *C. californiensis*. Dorsal prominences orange in five species, with or without black centers (variable in *chelidonia* and *californiensis* larvae). Setae P1 and P2 gray to black, lower setae banded white, black, white. Body colors and patterns described under the species.

Species Descriptions

Catocala andromache Henry Edwards

Ovum: A female collected July 12, 1978, in Kern River Canyon, Kern County, California, gave two ova. Their mean diameter was 1.27 mm, the mean number of ribs, 64, at greatest diameter. The ova darkened two days before hatching on April 14 and 15, 1979.

First instar: Larval length at eclosion, 7 mm. Head and cervical sclerites dark brown, setae black. Body pale brown, markings very dark brown, becoming black later. Setae black, bases brown. On segments A1 to A4, a faint middorsal line. Along upper sides, three narrow, longitudinal lines. On lower sides, oblique dashes dorsad and caudad from thoracic SV1 setae; horizontal dashes through and below lower, lateral, abdominal setae. Large patches enclosing spiracles on A1 to A6.

Thoracic legs pale brown, tarsi black; abdominal legs pale brown. Venter whitish, median spots dark brown.

Second instar: (Figure 3A) Head medium gray, pattern lines in black. Upper setae black, lower setae white. Coronal and frontal sutures, and frons-clypeus midline narrowly black. Other characters as described under shared traits.

Body medium gray, with heavy dark gray and black pattern. Setae and bases black. Dorsum with dark gray midline bordered by straight, narrow, white dashes of equal length, these in turn bordered laterad, at the breaks, by similar dark gray dashes. Five dark gray and black longitudinal lines on the sides, the uppermost through dorsal setae from TI to A10 and anal valve. Ventrad four more lines through or between setae, all lines separated by pale gray; line 5 continuing on the anal leg. Dark gray lateral patches on A1 to A6. Segments A7, A8 and A9 with transverse dorsal ridges bearing the conical D2 setal bases, ridge and setae largest on A8. Thoracic legs black laterally, tarsi black; prolegs of A5 and A6 vertically striped. Venter pale gray, median spots black.

Third instar: Head as in second instar. Dorsal prominences evident above setae P1. Dorsal bar brown between setae P1 and P2, black from seta P2 caudad on vertex. Body without lateral patches. Segment A5 with a flattened black, middorsal tubercle, the center yellow. From tubercle, black stippling laterad, forming a patch on side between A5 and A6, to prolegs. Ventral filaments white.

Fourth instar: Much as in third instar. Head and body overall, dark gray.

Fifth instar: (Figures 3B and 4A) Head medium gray on vertex and genae, front white. Dorsal prominences orange, with black centers. P1 and P2 setae black, other setae white-and-black banded. Pattern lines mostly dark gray. Dorsal bars from setae P2 caudad, narrow, sinuous, gray. Transverse vertex lines narrow, gray, interconnected, the more caudal deleted near coronal suture. Genae reticulate. Line 1, of frontal rim, black dorsally, dark gray laterally. Line 2 heavy, black. Vivid orange between lines 1 and 2 dorsally and upper laterally. Coronal and adfrontal sutures black, frontal suture gray dorsad, black ventrad; frons-clypeus midline black.

Body color medium gray, with heavy dark gray and black stippling. Cervical sclerites dark gray, setae white-ringed. Dorsal and upper lateral setae black, dorsal setal bases orange, white-ringed; lower setae white. Middorsal line black, bordered by white; the white, bordered by gray; the gray, bordered laterally by a sinuous, heavy, black line, forming an undulating edge to the dorsum. A series of indistinct, interrupted, narrow longitudinal lines on the sides, separated by gray lenses. Tubercle of A5 short, black-stippled, center white with black dot. From tubercle, heavy black stippling laterad and ventrad between A5 and A6, to prolegs. On A7 to A9 transverse dorsal ridges with conical, orange D2 setal bases, ridges of A7 and A8 black-edged, black continuing ventrad and forward toward spiracles, ridge and setae largest on A8. Spiracles yellow. Thoracic legs black-lined, tarsi black. Prolegs and anal legs gray, setae white-ringed; anal legs black-stippled dorsally, heavily edged in black. Ventral filaments pink. Venter whitish, median spots dark brown.

Other data: Both larvae were identical in all instars. One adult male emerged June 13, 1979 (Figure 4B). The probable foodplants in Kern Canyon are: *Quercus wislizenii* Greene (Munz, 1974); on desert slopes, *Quercus turbinella californica* Tucker; on coastal slopes *Quercus wislizenii* and *Quercus dumosa* Nutt. The flight period begins about June 7 at 600 meters and after July 1 at 1500 meters. The species lives below the montane forest. It is known from San Diego County through

through the coastal ranges and the Sierras to Amador County, where the subspecies *wellsi* Johnson (1983) replaces the lighter gray nominate *andromache* of southern California.

Catocala benjamini Brower

Ova: Two ova were obtained from a female collected in 1977 by Erich Walter at Pinyon Flat in the Santa Rosa Mountains, Riverside County, California. The ovum mean diameter was 1.28 mm, the mean number of ribs, 53, at greatest diameter. One ovum eclosed March 28, 1978.

First instar: (Figure 2) Larval length at eclosion, 6.5 mm. Head and cervical sclerites dark brown, setae black. The body whitish, with pale gray dorsum the setae black. On the sides, four longitudinal, dark brown lines, the uppermost through the dorsal setae. Ventrals, three more lines, line 4 short, through the abdominal L2 setae. All lines interrupted at A7, continuing on A8 and A9. Oblique brown dashes rising dorsad and caudad from the thoracic SV1 setae. Horizontal dashes subventrally on the abdomen. On segments A1 to A6, and on A8, large, lateral, dark brown patches. Thoracic legs with black tarsi, abdominal legs pale. Venter pale gray, median spots dark brown. Pattern lines, spots and patches becoming black later.

Second instar: (Figure 3C) Head whitish, setae and bases black. Lines black, genae reticulate. Coronal and frontal sutures and frons-clypeus midline narrowly black.

Body white, setae and bases black, unlike first instar. Middorsal line pale gray from T1 to A9. At each side, and down the sides, broad, even, equal, frosty-white, longitudinal stripes, separated by narrow, parallel, gray-stippled lines about two dots wide, from T1 to A10. No lateral patches on the abdomen. A8 and A9 with transverse dorsal ridges with conical D2 setal bases. Thoracic tibiae and tarsi black, prolegs whitish, anal legs black-striped. Venter white, median spots black.

Third instar: Much as in second instar. Head nearly white, upper genae with light brown patches, unlike the other species. The lines rimming the front, heavily black. Upper setae black, lower setae white. A prominence above seta P1. Body pale gray, setae and bases black. On A7 to A9 setal bases of D2 setae brown, conical. Middorsal line black-stippled, forming diamond-shaped patches on segments. Body with alternating regular, longitudinal, equal stripes of white and less-white body color, separated by narrow lines of black stippling. On A5 a small, flattened, brown, middorsal tubercle. From tubercle laterad, black stippling, on sides forming patches between A5 and A6, to the prolegs. Ventral filaments white.

Fourth instar: Much as in the third instar, progressing toward the fifth instar pattern.

Fifth instar: (Figures 3D and 4C) Head pale gray, pattern in dark gray and black. Setae P1 and P2 black, other setae banded. P1 and P2 setal bases orange-ringed, head clear white around the setae. Dorsal prominences yellow orange, front white. Vertex dark gray posteriorly; dorsal bars black from the P2 setae caudad. The subparallel, transverse lines of the vertex narrow, interconnected, gray mesad, black laterad across bar, gray ventrad, forming a genal reticulum. Line 1 of the frontal rim gray, but black adjacent to dorsal bar. Line 2 black dorsally, gray laterally. Vivid orange between the lines dorsally, absent in white area by seta P2,

again orange upper laterally. Coronal suture narrowly black, frontal and adfrontal sutures, and frons-clypeus midline, heavily black.

Body light gray, with undulating, indistinct, narrow, stippled black lines separating stripes of slightly lighter, and slightly darker body color. Middorsal line black. Dorsal and upper lateral setae black, lower setae white. All dorsal, subdorsal and upper lateral setae with raised orange bases. Segment A5 with a flattened, black-stippled, middorsal tubercle, the center gray. Laterally, between A5 and A6, gray and black stippling, forming patches on A6, with patches of light and dark brown stippling. Transverse dorsal ridges with large, orange D2 setal bases on A8 and A9, on A8 the ridge edge black-stippled, the stippling continued ventrad toward the spiracles. Spiracles yellow. Thoracic legs black-striped. Prolegs of A5 and A6 vertically gray-striped anteriorly, black-striped posteriorly; anal legs dorsally and laterally black-striped. Ventral filaments white; venter white, median spots black.

Other data: An adult male was reared from the ovum, emerging May 25, 1978 (Figure 4D). *Catocala benjamini* associates with the *Quercus turbinella californica* woodland on the desert slopes of the mountains from San Diego to Los Angeles

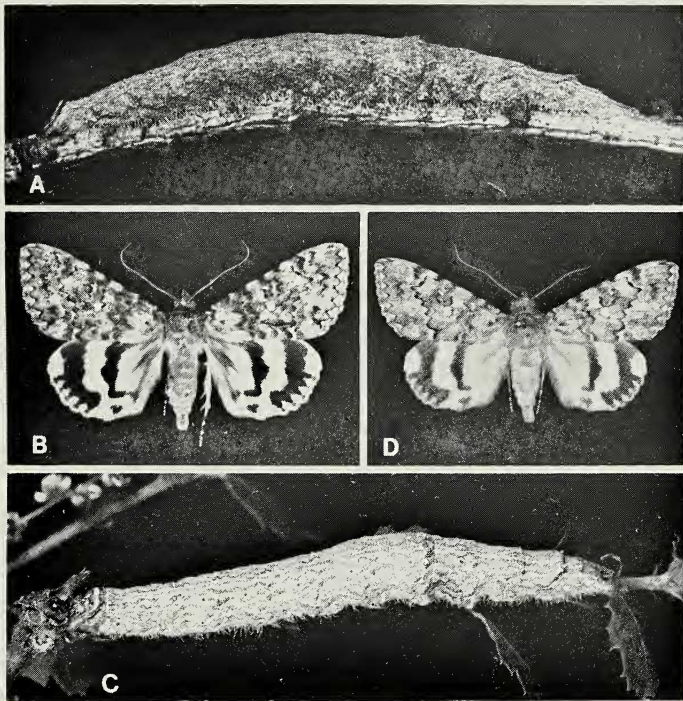


Fig. 4. **A.** *Catocala andromache* fifth instar larva, length 46 mm; **B.** the corresponding reared adult male, wing span 52 mm; **C.** *Catocala benjamini* fifth instar larva, length 42 mm; **D.** the corresponding reared adult male, wing span 48 mm.

Counties, and with *Quercus turbinella turbinella* Greene in the Providence and New York Mountains of the eastern Mohave Desert. At Pinyon Flat the flight period begins about June 1.

Catocala californiensis Brower

Ova: Females collected at Pinyon Flat, in the Santa Rosa Mountains, Riverside County, California, in 1978, yielded 46 ova. The ovum mean diameter was 1.16 mm, the mean number of ribs, 54, at greatest diameter. Three ova eclosed April 7, 10 and 30, 1979. The first larva accepted the substitute foodplant, *Quercus dumosa*. The others did not feed, and died.

First instar: Length of the larva at eclosion, 5.5 mm. Head and cervical sclerites jet black, setae black. Body pale gray; dorsal and lateral setae and bases black, ventral setae white from black bases. A faint, discontinuous, middorsal dark line from T1 to A10. On upper sides, three narrow, interrupted, longitudinal black lines, the uppermost through the dorsal setae. Large, black patches on A1 to A9, patches largest on A1 to A6. Horizontal, black dashes through thoracic and abdominal lower lateral setae and subventrally. Thoracic tibiae and tarsi black; prolegs and anal legs pale gray. Venter white, median spots black.

Second instar: (Figure 5A) Head medium gray, setae black. Genae reticulate, coronal and frontal sutures, and frons-clypeus midline, black.

Body whitish; setae and bases black, bases of the SD1 and L2 setae prominent on abdomen. Dorsum with a wide, pale-gray, middorsal stripe, divided by a narrow, white, interrupted midline. At the interruptions, short, narrow, white dashes at either side. On upper sides, three longitudinal dark gray lines, the uppermost heavy, through the dorsal setae, interrupted. On lower sides, horizontal dashes through setae and below. On A1 to A6, oval, dark gray patches. Between A5 and A6, dark gray stippling laterad from middorsal stripe, ventrad on sides to prolegs. Thoracic legs laterally black-accented, tibiae and tarsi black; prolegs flecked with black. Venter white, median spots black.

Third instar: Much as in second instar. Head pale gray, upper setae black, lower white. Bar between setae P1 and P2 deleted. A prominence dorsad of seta P1. No lateral abdominal patches. No middorsal tubercle on A5. Black stippling across dorsum of A5, on sides of A5 and A6 forming patches, reinforced by the longitudinal lines, to prolegs. Ventral filaments white.

Fourth instar: Progressing towards fifth instar. a middorsal tubercle on A5. Inconspicuous lateral gray patches on A1 to A6.

Fifth instar: (Figures 5B and 6A) Larva overall very white. Head: vertex pale gray, front and genae white. Lines of pattern medium gray. Dorsal bars from P2 setae sinuous, narrow, gray. The transverse, subparallel lines of vertex gray, interconnected, attenuated near coronal suture, laterad forming a reticulum on genae, becoming black ventrad. Line 1, of frontal rim, black at coronal suture, then gray, black near seta P2, gray laterad. Line 2 heavily black. Space between lines 1 and 2 orange dorsally and upper laterally. Setae P1 and P2 black, other setae banded. Bases of setae P1 and P2 orange-ringed. Dorsal prominences with orange patches, center black in two larvae, orange in one. Coronal and frontal sutures black, frons-clypeus midline black, becoming gray ventrad. Adfrontal sutures heavily black, an inverted black sagittate patch at apex of adfrontal sclerites.

Body white, dorsal setae black, others white. Bases of dorsal and subdorsal setae orange, other setal bases black. Dorsal setal bases prominent. Middorsal line

black, narrow, interrupted, from TII to A10, and to anal valve. To either side, a dorsal, longitudinal, sinuous black-stippled line mesad from dorsal setae. Next laterad, a longitudinal, interrupted, narrow black line tangent laterally to D1 setae, and through D2 setae. Ventrad, five more narrow, interrupted, longitudinal black lines. Between uppermost lateral line and line 2, and between lines 3 and 4, through spiracles, gray-stippled stripes, contrasting with white of body. Rising dorsad and caudad on sides of thorax and abdomen oblique, narrow, black lines passing through D2 setae, caudad of setae becoming heavy, black, short bars, convergent toward the dorsal midline on segments TII to A8. Middorsal tubercle of A5 flattened, white, with black stippling. From tubercle laterad, black stippling forming patches on sides of A5 and A6, to prolegs. an upwardly convex, strong, black crescent between spiracles on A5 and A6. On sides, from TII to A7, irregular darker patches, the patches intensified on abdomen as a bar between SD1 setae and L1 setae, crossing the spiracles obliquely. Segments A7 to A9 with transverse ridges bearing large, conical, orange D2 setal bases, ridges edged in black stippling; on A8, stippling continuing ventrad and cephalad to SD1 seta. Thoracic legs laterally black-accented, tarsi black. Prolegs of A3 and A4 with lateral, dark gray accents, prolegs of A5 and A6 vertically black-striped anteriorly and posteriorly, anal leg doubly black-striped. Spiracles yellow. Ventral filaments white. Venter white, median spots black.

Other Data: From the one ovum an adult male was reared (Figure 6B). It emerged June 8, 1979. A male and female *C. californiensis* were reared from two prepupal larvae collected at Pinyon Flat under shrubs of *Quercus turbinella californica* Tucker (Munz, 1974). *Catocala californiensis* is found on the desert slopes of the mountains from San Diego County to Los Angeles County, and in the woodland of *Quercus alvordiana* Eastw. in the Cuyama Valley, Ventura County. At Pinyon Flat the flight period begins about June 1.

***Catocala johnsoniana* Brower**

Ova: Four ova were obtained from a female collected in 1978 in Kern River Canyon, Kern County, California. One ovum measured 1.29 mm in diameter, with 75 ribs at greatest diameter. The ribs were very narrow, and in low relief, making the egg smoother than those of other species. One ovum was fertile; it darkened two days before hatching on April 10, 1979.

First instar: The single first instar larva measured 6.5 mm at eclosion. Head and cervical sclerites jet black, setae black. Body medium gray, with heavy, black markings, making larva dark gray overall. Body setae and bases black. Dorsum medium gray with no midline. On uppersides three interrupted longitudinal lines, the uppermost tangent laterally to D1 setae, and through D2 setae, to A10. Line 2 above, and line 3 through, the subdorsal setae. On lower sides horizontal dashes at thoracic and abdominal setae. On sides of A1 to A6 large black patches, largest on A1 to A4. Thoracic tibiae and tarsi black, abdominal legs dark gray. Venter pale gray, median spots black.

Second instar: (Figure 5C) Head pale gray, heavily black-lined, appearing dark gray. Setae black. Genae reticulate; coronal suture, frontal suture, and frons-clypeus midline black.

Body pale gray, appearing dark gray because of heavily-black pattern; cervical sclerites black. Setae and bases black. On upper sides three longitudinal lines, the

uppermost, somewhat double, dark gray and black, through the dorsal setae. Second line dark gray, linked with line 1 at A7. Third line forming an interrupted series of oblique black dashes through SD1 setae, caudad and ventrad, to end at L1 setae of following segments, repeating to A6, and on A8 and A9. On lower sides interrupted, dark gray or black, horizontal dashes through and below setae. On A7, A8 and A9 transverse dorsal ridges bearing conical D2 setal bases. Thoracic tibiae and tarsi black, prolegs with black patches, anal legs laterally black-striped. Venter white, median spots black.

Third instar: Head as in second instar, pattern lines in dark gray and black. Black bars of vertex now from setae P2 caudad to rear margin. Setae P1 on dorso-ventrally-elongated dark gray spots. Upper setae black, lower, white. Body much as in the second instar, overall dark gray. Upper setae black, lower white. Middorsal line strongly black. A series of about six indistinct longitudinal, generally parallel, black lines on sides. No middorsal tubercle on A5. Across dorsum of A5, and down sides between A5 and A6, dark gray shading, to prolegs. Dark gray lateral patches on A1 to A5. Ventral filaments sparse, short, white.

Fourth instar: Much as in third instar. From sides of thorax and abdomen a series of oblique narrow black lines rising dorsad and caudad through D2 setae, intensified caudad of setae on dorsum as short black bars, those of the two sides convergent toward middorsal line. On A5 a flattened, brownish gray, black-stippled, middorsal tubercle. No lateral patches.

Fifth instar: Larva dark gray overall (Figures 5D and 6C). Head vertex and upper genae medium gray, front and lower genae white. Setae P1 and P2 black. Other setae banded. Base of seta P1 black, of P2, orange-ringed. Prominence dorsad of seta P1 white, with orange patch and black center, patch tangent to P1 setal base. Dorsal bars sinuous, narrow, gray, from seta P2 to vertex rear margin. The sets of transverse lines on vertex, sinuous, interconnected, gray, the more posterior incomplete toward coronal suture, laterad passing into genal reticulum. Line 1, of the two lines rimming the face, black dorsally, gray laterally. Line 2, heavily black. Vivid orange filling between lines 1 and 2 dorsally and upper laterally. Coronal and frontal sutures narrowly black, frons-clypeus white with midline dark brown, bordered by gray dashes. Adfrontal sutures heavily black, adfrontal sclerites dark gray, with inverted sagittate, dark gray patch dorsad.

Body medium gray; cervical sclerites gray with setal bases white-ringed. Dorsal and upper lateral setae black, bases orange, D2 setae and bases largest; lower setae white. Middorsal line stippled, black; at either side light and dark gray stippings. More laterad a dorsal longitudinal, sinuous black line through thoracic D1 setae, and mesad of abdominal dorsal setae to A10. On sides, four longitudinal, black lines, the uppermost through dorsal setae, the lines separated by gray stippling; fourth line through the L1 setae. Through spiracles, a longitudinal dark gray stripe between lines 3 and 4. On lower sides gray and black stippings, darker above white ventral filaments. From sides of thorax and abdomen narrow oblique black lines rise dorsad and caudad through D2 setae, becoming short heavy dashes caudad of setae, those of the two sides convergent toward the dorsal midline. Middorsal tubercle on A5 pale brown, flattened, black-stippled, stippling continuing laterad and down sides of A5 and A6, reinforced at the longitudinal lines and stripes as patches, to prolegs. Segments A7 to A9 with transverse dorsal ridges between the enlarged, conical, orange D2 setal bases; ridge of A8 stippled in gray and black, stippling continuing laterad forward to SD1 seta. Thoracic legs dark gray, laterally

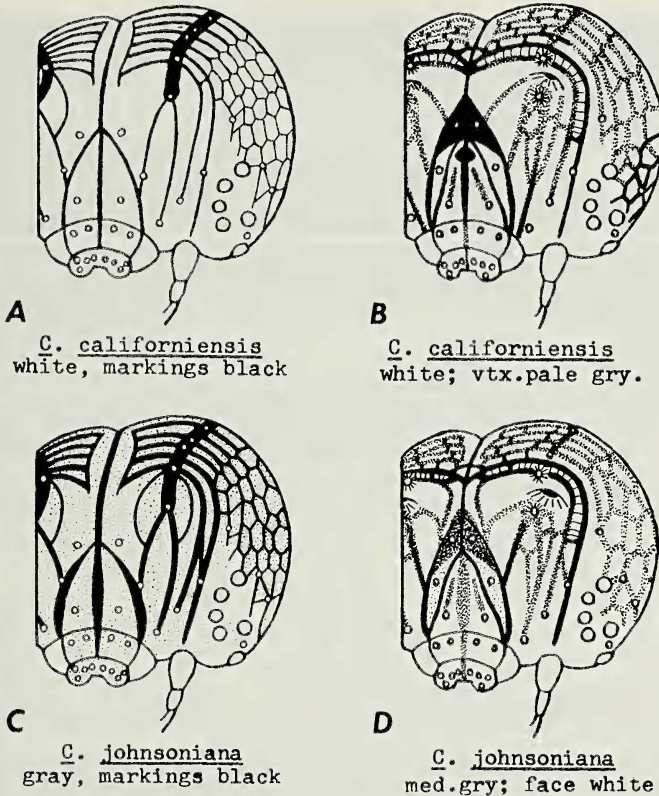


Fig. 5. Schemata of the head patterns of: **A.** *Catocala californiensis* second instar; **B.** same, fifth instar; **C.** *Catocala johnsoniana* second instar; **D.** same, fifth instar. Small circles, setal bases; large circles, ocelli. On fifth instar heads: stippled lines, gray; solid black, black; hatching between the lines of the facial rim, rays around setal bases and prominence above seta P1, orange. In *C. johnsoniana* the frons-clypeus midline is brown.

black-lined. Abdominal legs with dark gray patches and stippings. Spiracles yellow. Venter white, median spots black.

Other data: An adult female was reared from the one ovum. it emerged June 9, 1979 (Figure 6D). *Catocala johnsoniana* has been collected at Hughes Lake, Los Angeles County; Kern Canyon, Kern County (several collectors); Coarse Gold, Madera County (Erich Walter); and Don Pedro Reservoir Recreation Area, Tuolumne County (J. R. Mori). It inhabits the Blue Oak woodland surrounding the California Central Valley. Besides the Blue Oak, *Quercus douglasii* H. and A., the woodland includes *Quercus lobata* Nee., and *Quercus wislizenii* A. DC. The foodplant is unknown. The flight period begins before that of *C. andromache* in the same area.

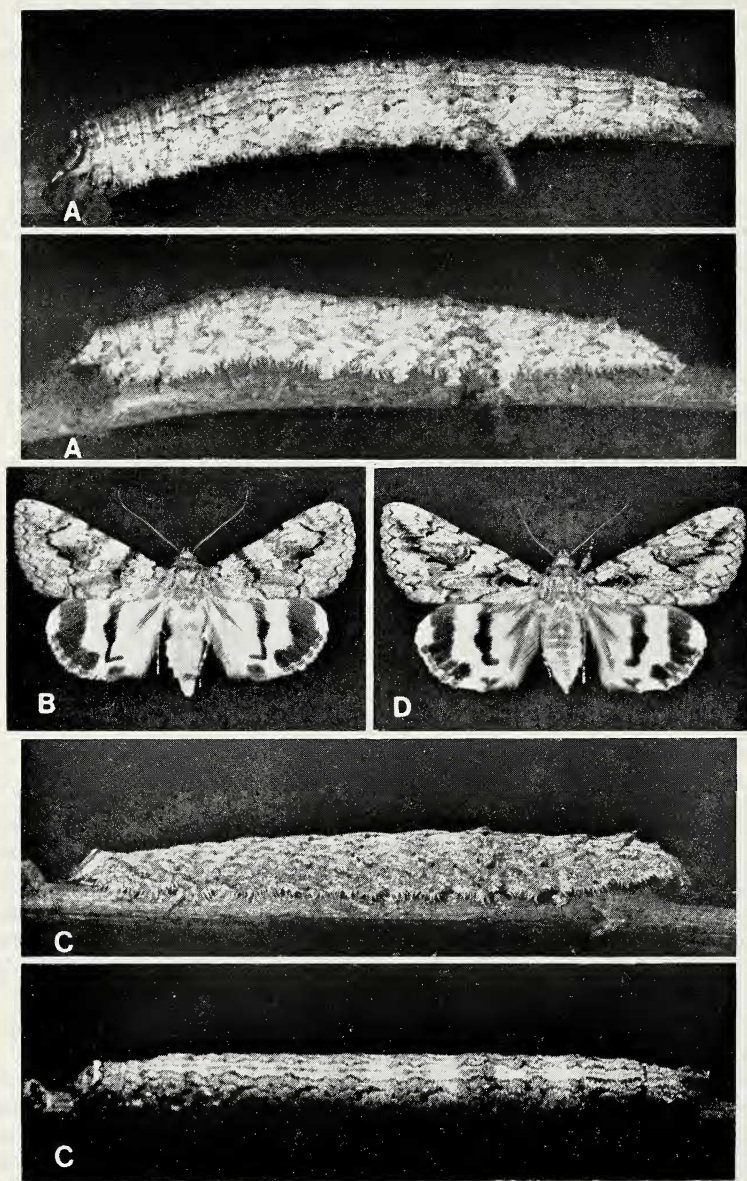


Fig. 6. **A.** *Catocala californiensis*, views of the fifth instar larva, length 37 mm; **B.** the corresponding reared adult male, wing span 46 mm; **C.** *Catocala johnsoniana*, views of the fifth instar larva, length 44 mm; **D.** the corresponding reared adult female, wingspan 50 mm.

Catocala chelidonia Grote

Only the fifth instar larvae of *C. chelidonia* were described by Crumb (1956). In 1978 and 1979 the author reared the species from ova to adults, and so the other stages may now be described.

Ova: Sixty-nine ova were obtained from 10 captive females collected at Pinyon Flat in the Santa Rosa Mountains, Riverside County, California, in 1977 and 1978. Of these, 42 were fertile, hatching from April 11 to May 22. Of the larvae, 15 pupated, producing 11 adults. The ovum mean diameter measured 1.02 mm, with a mean of 64 ribs at greatest diameter.

First instar: The larvae measured 5 mm at eclosion. Head and cervical sclerites dark brown, setae black. Body whitish, setae black, bases brown. A wide longitudinal, unmarked stripe on dorsum between the lines through dorsal setae. On upper sides three longitudinal, black lines, line 2 most continuous; line 3 continuous on thorax, on abdomen forming a series of oblique dashes through SD1 setae, caudad and ventrad, ending on L1 setae of following segments, repeating to A9, absent on A7. Large, lateral, black patches on A1 to A5, smaller on A6 and A8. Thoracic legs white. Prolegs of A5 and A6 vertically striped in dark brown; anal legs brown-striped laterally. Anal valve brown. Venter white, median spots dark brown. Body markings darkening to black later.

Second instar: (Figure 7A) Head pale gray, upper setae black, lower white. Pattern lines black. Across vertex and ventrad on genae, a set of parallel lines, little interrupted, unlike the reticulate genae of four species. Coronal, frontal sutures, frons-clypeus midline, black.

Body pale gray, setae and bases black, setal bases prominent. The pattern much as in first instar. Dorsum more gray than sides; a middorsal line from T1 to anal valve, paralleled by narrow, dorsal, discontinuous, dark gray lines through thoracic D1 setae and mesad from abdominal dorsal setae to A8. On upper sides, three longitudinal, interrupted, black lines, the uppermost through dorsal setae, the most ventrad forming a series of oblique dashes through SD1 setae. Short, oblique, black dashes rising caudad from thoracic SV1 setae. On abdomen, horizontal dashes through lower setae. Large, black patches on A1 to A6, and A8. On A7 to A9, transverse dorsal ridges between the conical D2 setal bases. Thoracic legs black accented, tarsi gray. Prolegs of A5 and A6 gray. Anal legs with heavy, black dorsal stripes, laterally doubly black-lined. Venter white, median spots black.

Third instar: Head white, lines black, like second instar. White prominences dorsad of setae P1. Genae reticulate above, parallel-lined below. Body pale gray, or gray cephalad and brown caudad, or entirely pale brown. Brown phases appearing in larvae confined in dim light. Middorsal line black. Laterad and down sides, six interrupted, longitudinal, black, or, on brown larvae, dark brown, lines; the first line on dorsum mesad from dorsal setae. Between lines 1 and 2 through dorsal setae, the body darker, making a dorsal, longitudinal, dark stripe to either side of the pale gray middorsal area and black midline. A5 with black-stippled tubercle, the center pale gray. From tubercle laterad, black stippling on sides, forming gray and black patches in gray larvae, and orange and brown patches in brown larvae, to prolegs. Single, white, ventral filaments on A1 to A5.

Fourth instar: Much as in third instar. Ventral filaments numerous.

Fifth instar: (Figures 7B and 8A) Head whitish, setae P1 and P2 black, others banded. Prominences dorsad and laterad of setae P1, orange, with or without black

center. An orange bar between setae P1 and P2, P1 base black, P2 base orange, ringed by yellow, the head pale yellow around setae. Dorsal bar narrow, sinuous, gray from seta P2 caudad to vertex rear margin. Transverse lines of vertex gray, interconnected, reduced near coronal suture, laterad anastomosing on upper genae, joining parallel lines ventrad, forward to ocelli. Frontal pattern like the other species. Pair of lines rimming front gray dorsally, black adjacent to seta P2, gray, or gray and black laterally. No orange between lines. Adfrontal sclerites white, adfrontal sutures heavily dark gray, to black. Coronal, frontal sutures, narrowly dark gray, to black. Frons-clypeus mesally white, laterally gray, midline black.

Body, whitish, or pale brown, lines gray and black, or brown. Cervical sclerites gray, setal bases orange, white-ringed. Dorsal and upper lateral setae black, bases orange; lower setae white, bases black on thorax, yellow on abdomen. Middorsal line black, bordered by pale gray or pale brown stripes. Three longitudinal lines in black, or brown, on the upper sides from T1 to A9, or A10, the uppermost through dorsal setae interrupted. Line 2 black or dark brown, bordered by gray and black, or brown, forming a longitudinal stripe to A10. Line 3 gray and black, or brown, interrupted. Longitudinal dashes in gray and black, or brown on the sides. On A5, a short erect, black stippled middorsal tubercle, center orange-brown to pale brown, the tubercle on a transverse black-stippled ridge, stippling continuing ventrad on the sides of A5 and A6, forming interrupted, oblique patches, becoming brown, to prolegs. Tubercle and lateral patches on A5 and A6, most prominent of six species. On A8 and A9 prominent transverse dorsal ridges between large, conical D2 setal bases. Ridge of A8 margined in orange-brown, black-stippled, stippling continued ventrad forward to SD1 seta. Thoracic leg tibiae black-lined, tarsi black. Prolegs of A3 and A4 pale gray, or brown, with dark accents; prolegs of A5 and A6 laterally mottled in dark shades. Anal legs stippled darkly dorsally, and laterally striped in dark gray. Setal bases of thoracic and abdominal legs white-ringed. Spiracles yellow. Ventral filaments white; venter whitish, or pale brown, median spots very dark brown, edged in vivid dark red.

Other data: From the first ovum an adult female was reared. It emerged June 9, 1978. Ten adults were obtained in 1979 (Figure 8B). In California, *C. chelidonia* is known from the desert slopes of the mountains of San Diego and Riverside Counties where it inhabits the *Quercus turbinella californica* woodland that includes *Agave deserti* Engelm., the agave being a reported nectar plant for *C. chelidonia* (Barnes and McDunnough, 1918, p. 33).

Comparison of Arizona and California *C. chelidonia* Larvae

Crumb's (1956) *chelidonia* larvae were from Arizona. The larvae from California differ in a number of traits.

Arizona *chelidonia* larvae range in color from pale gray to blackish; the California larvae that were reared were pale gray or pale brown. The heads of Arizona larvae have white or orange prominences, California larvae show orange prominences. The most dorsal large setae from black spots in Arizona larvae, and from orange and yellow rings in California larvae. Arizona larval heads have double black lines rimming the face; those of California, double gray lines. The occiputs (vertices) of Arizona larvae are reticulate; those of California larvae are subparallel lined. No frontal inverted Vs are described for Arizona larvae, but are prominent head

features in California larvae. The genae of California larvae are parallel-lined below (no data for Arizona larvae). The thorax in Arizona larvae has a dark shade dorsally on TII, no shade present in California larvae. In Arizona larvae the A5 middorsal tubercle is long, drooping posteriorly; the tubercle is short, and erect in California larvae. The spiracles of Arizona larvae are brown, of California larvae, yellow. The venter of Arizona larvae is blue, with purple median spots. California larvae have white or pale brown venters, with dark brown median spots edged in vivid dark red.

Catocala mcdunnoughi Brower

Ova: One ovum was yielded by a female collected in Potato Canyon in the San Bernardino Mountains, San Bernardino County, California, in 1978. The diameter measured 1.27 mm; the ribs numbered 61 at greatest diameter. The ovum changed from yellow to golden brown two days before hatching on May 14, 1979.

First instar: The length at the first feeding, 7 mm. Head and cervical sclerites, golden brown, setae black. Body pale yellow, lines of the pattern in bright brown. Setae and bases black. Dorsum yellow, forming a wide longitudinal stripe between the lines through dorsal setae, as in *chelidonia*. On dorsum a faint, narrow, brown midline. On upper sides, three longitudinal lines, the uppermost through dorsal setae, interrupted; line 2 more continuous, to A10 and down anal leg. Line 3 forming a series of oblique dashes through SD1 setae, caudad and ventrad, ending on L1 setae of following segments, repeating to A9, absent on A7. On lower sides horizontal dashes through L2 setae and subventrally, lowest continuing as a broad stripe on anal leg. On A1 to A5 large lateral brown patches, A6 patch smaller. Thoracic legs white, tarsi brown; prolegs, with lateral, dark-brown patches; anal legs with brown patches and stripes. Venter pale yellow, median spots dark brown. Larva golden brown overall, like the golden brown young shoots of *Quercus chrysolepis* Liebm.

Second instar: (Figure 7C) Head pale yellow, pattern brown. Vertex yellow, unmarked. From its lateral edges arise anastomosing dark brown lines, of these, two form a lateral rim on front. Other lines descend subparallel on genae, forward to ocelli. No vertex bars from P1 and P2 setae to caudal margin. The frontal pattern with inverted Vs incomplete dorsally. Coronal, frontal sutures, frons-clypeus midline, dark brown.

Body pale golden yellow, pattern in brown. Cervical sclerites pale yellow, brown-edged. Setae and bases, black. Middorsal line brown. To either side a dorsal, longitudinal line through thoracic D1 setae and mesad from abdominal dorsal setae. On sides, five longitudinal lines, the uppermost through dorsal setae. Lines 4 and 5, interrupted. More ventrad, a final series of horizontal dashes through the L3 setae. On A1 to A5, brown lateral patches. On A8 and A9 transverse dorsal ridges between the prominent D2 setal bases. Thoracic legs yellow, tarsi brown. Prolegs and anal legs yellow. Prolegs brown-accented, anal legs striped. Venter pale yellow, median spots dark brown.

Third instar: Head white, pattern lines dark brown, much as in second instar, caudal margin black. On vertex, narrow brown loops along brown coronal suture. Orange bar between setae P1 and P2. On genae, parallel brownish-black lines. On front, complete inverted Vs. Upper setae black, lower setae white. Body similar to the second instar, lateral patches now pale gray, indistinct. No middorsal tubercle

on A5. D2 setal bases on A8 black, ringed in orange-brown; on A9, ringed in brown. No ventral filaments.

Fourth instar: Lines of the head in gray and black. Vertex crossed by six transverse subparallel lines from irregular lines by coronal suture; the transverse lines faint caudad of P2 setae, laterad forming a reticulum on upper genae, joining parallel lines below. Front rimmed by a gray and a black line, frontal pattern gray. Body similar to third instar. Ventral filaments white, short, sparse; no lateral patches. No A5 middorsal tubercle.

Fifth instar: (Figures 7D and 8C) Head white with yellow and black caudal margin. Setae P2 and L1 dark gray, P1 light gray, others white. P1 and P2 setal bases ringed by orange, orange continuous from P1 to orange prominence dorsad from P1. Vertex transverse lines gray, subparallel, interconnected, arising from an

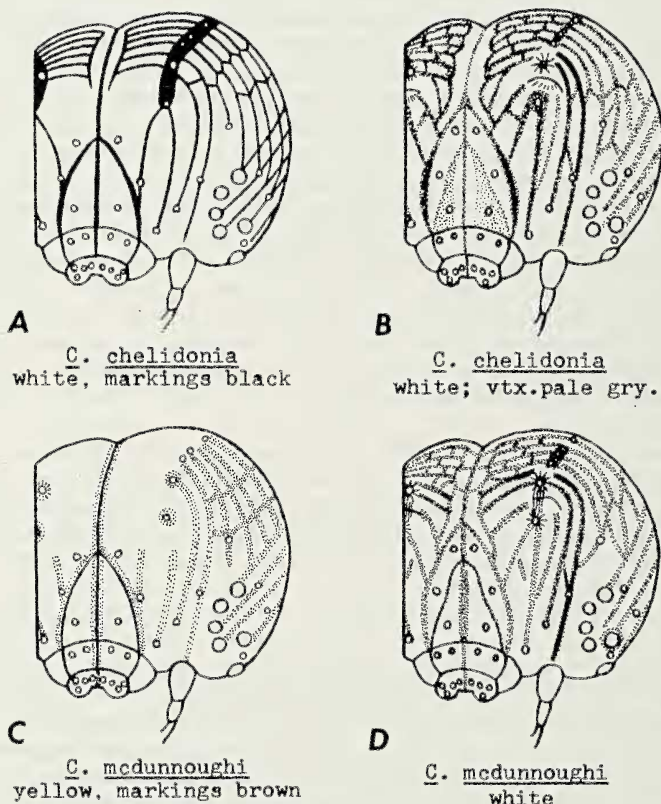


Fig. 7. Schemata of the head patterns of: **A.** *Catocala chelidonia* second instar; **B.** same, fifth instar; **C.** *Catocala mcdunnoughi* second instar; **D.** same, fifth instar. Small circles, setal bases; large circles, ocelli. On fifth instar heads: stippled lines, gray; solid black, black; hatching between the lines of the facial rim, rays around setal bases and prominence above seta P1, orange.

irregular line by coronal suture. Upper genae, reticulate; below, the lines sub-parallel, forward to ocelli. Short gray bars on the vertex between setae V1 and V2. Lines rimming front gray dorsally and laterally, no orange color between them. The coronal, adfrontal, and frontal sutures gray, frontal suture arms nearly black ventrad. Frons-clypeus midline gray.

Body nearly white; cervical sclerites gray, their setal bases white-ringed. Upper body setae dark gray, lower, white. Dorsal and lateral setal bases orange, prominent, on TII to A9. On TI and A10 the setal bases black, less prominent. Middorsal line gray and black. To either side, and on sides, seven indistinct, narrow, longitudinal, gray and black lines. Between lines, longitudinal, stippled lineations; all lines subdued, larva appearing white. Segment A5 swollen, tubercle replaced by a smooth transverse swelling. Narrow, black stippling on the intersegmental membrane between A5 and A6. A8 transverse dorsal ridge prominent, meeting a longitudinal raised fold middorsally, forming a T. A8 D2 setal bases orange, conical. Ridge and setae lesser on A9. Thoracic legs with lateral brown patches, leg setae from white basal rings. Prolegs and anal legs pale gray, the setae from white basal rings. Prolegs narrowly, vertically, brown striped; anal legs brown-stippled and with narrow, brown, lateral lines. Spiracles yellow. Ventral filaments white. Venter white, median spots brown. The smooth white larva, with node-like head and

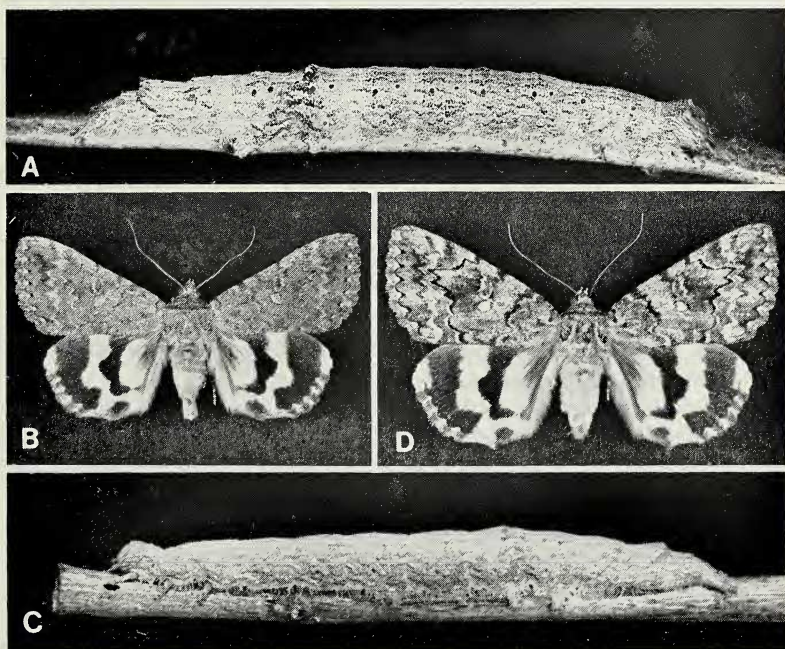


Fig. 8. **A.** *Catocala chelidonia* fifth instar gray larva, length 37 mm; **B.** same, adult male from a gray larva, wing span 48 mm; **C.** *Catocala mcdunnoughi* fifth instar larva, length 52 mm; **D.** same, adult female from the larva, wing span 52 mm.

small prothorax, blends well with the smooth, white branchlets of *Quercus chrysolepis*.

Other data: From the one ovum a female was reared, the moth emerging July 2, 1979 (Figure 8D). The species is found in the montane forest from San Diego County northward to the northern Sierra Nevada Range in Amador County, where the subspecies *browerarum* Johnson (1983) with green-scaled, very dark brown wings replaces the typical, medium-brown populations of southern California. The foodplant surely is *Quercus chrysolepis*, to which the larval coloration is perfectly adapted, and which, in some habitats, is the only oak available for the *C. mcdunnoughi* populations that exist there. The flight period, in southern California, begins after July 15; in central California, from June 20, onward.

Discussion

1. Rearing Observations

Females of the six species were confined in large paper bags and two-liter cardboard cylinders with open, net-covered ends. They were fed nightly with sugar water in cotton and with watermelon slices. Open windows maintained normal temperature and humidity ranges in the room. Each container held a sprig of foodplant stapled to a corrugated cardboard square wrapped loosely in netting. Ova were found in the netting, in holes of the cardboard edges, on container surfaces, in seams and corners, but never on foliage. Oviposition success was about the same in both container types. Moths lived from two to thirty-six days in captivity.

Captive females yielded ova infrequently. The percentage of fertile ova was low. As the captive females died, they were dissected to determine if their ova were exhausted. In 69 dissections, only one female was found without ova. It had laid one egg, the last, that proved to be fertile. Most females held numerous, fully-formed ova, with additional undeveloped ova. As many as 101 developed unlaidd ova per female were counted. It seems evident, that the reproductive potential of these small moths exceeds 100 ova per female.

To retard the eclosion of the ova before the opening of the buds of the foodplants, the ova were held outside most of the winter, and for the month of January put in refrigeration at about 5°C. Eclosion occurred at about the dates when oak buds open in nature.

1. The larvae were reared on foodplants held in glass cylinders with netting at the open ends. This permitted observation of the larvae at all times. In 1979 the 41 *C. chelidonia* larvae, when confined together, caused each other to drop from the foodplant. A number of larvae perished before regaining the foodplant. A change to confinement in small containers resulted in more losses to disease, perhaps the result of high humidities from the confined foliage. The surviving larvae were spread out in cylinders and wooden rearing boxes. Fourteen larvae reached pupation, producing ten adults. In the boxes, under low light

intensities, some of the *chelidonia* larvae at the third and later instars changed from gray to mottled gray and brown, or to brown coloration. None of the larvae in the well-lit cylinders changed color, remaining gray. Leaf litter was provided for pupation. All larvae pupated in the litter but one. The *C. johnsoniana* larva spun a tight cocoon well above the litter in the foodplant foliage.

Larval growth was rapid. The mean durations of the instars for five of the species were: first instar, five days; the second, four; the third, four; the fourth, four; the fifth instar to spinning, eight days. The mean length of the total larval period was 24.5 days. The pupal period from spinning to emergence averaged 35.7 days. For these species, larval development in nature may be about as rapid, as the reared adults emerged within the natural flight periods. The larva of *C. mcdunnoughi*, a high mountain species, in the coastal environment with mild nights, grew very rapidly, emerging as an adult well before the flight period in the mountains. Five species were reared on *Quercus dumosa*. *C. mcdunnoughi* was reared on *Quercus chrysolepis*.

Feeding behavior: First instar larvae fed both by day and night. Between feedings they rested beneath leaf edges, on veins, or on midribs. At rest the larvae attached themselves by the abdominal legs, the body forward of A5 being raised at a slight angle. The thorax and head were bent again parallel to the surface, with the thoracic legs appressed forward against the thorax, and the head extended, the front uppermost. In this attitude, and colored by consumed food, the larvae resembled closely the stipules of opening oak shoots. In the second instar feeding was done chiefly at night, the larvae resting, head downward, on leaf petioles and twigs between feedings. In older instars all feeding was done at night, the larvae resting by day on twigs, usually head downward. After periods of activity, in all instars, a pulsation between segments A8 and A9, in the form of a pinching-in of the sides, was observed at times.

2. Constancy of Larval Traits

While the number of larvae available for comparison was small, the larvae shared many traits, as well as exhibiting species differences in color and pattern details. The author has observed, in other species of California *Catocala*, that variations between larvae of a species in the first and second instars is minimal. The larval size, color and patterns are constant, and the larvae alike. It is believed that the species similarities and differences exhibited by the small sample of larvae in the first and second instars will be found to be valid when additional larvae are seen. Likewise, head patterns have much constancy in the second and later instars, even when variations are extensive in the body colors of the larvae of a species. The observed similarities and differences in head patterns should prove to be valid also.

Traits shared between the species in the first two instars, and in the head patterns from the second to final instars, indicate that the six species are closely allied. In the future, comparative studies of pupae, of adult wing patterns and forms (Johnson and Walter, 1980), of the male genitalia and of the internal and external female genitalia should afford further insights into the interrelationships of the six species.

3. Larval Keys

a. FIRST INSTAR LARVAE

- 1a. Body* pale yellow, all markings in bright brown, head golden brown.....*C. mcdunnoughi*
- 1b. Body white, pale brown, or gray, markings dark brown to black, heads dark brown to black.....2
- 2a. Body, overall, obviously dark in color3
- 2b. Body, overall, pale gray to whitish.....4
- 3a. Body ground color medium gray, no middorsal line, head shining jet black, dashes on the lower sides of the thorax and abdomen horizontal, all body markings and setal bases black from eclosion*C. johnsoniana*
- 3b. Body ground color pale brown, head dark brown, a short mid-dorsal line on A1-A4, dashes on the lower sides of thorax oblique, of abdomen horizontal, markings and setal bases brown at eclosion, becoming black later*C. andromache*
- 4a. Six black lateral patches, longitudinal line 3 on the abdomen interrupted as a series of oblique dashes through the SD1 setae to end on the L1 setae of following segments, repeating; head dark brown, body white, markings brown and black, becoming all black later*C. chelidonia*
- 4b. Seven or nine lateral patches, longitudinal line 3 horizontal, not a series of oblique dashes.....5
- 5a. Seven lateral patches, four longitudinal lines on sides of the body, head dark brown, lines and setal bases black, ventral spots dark brown, darkening to black later.....*C. benjamini*
- 5b. Nine lateral patches, three longitudinal lines on the sides of the body, head shining jet black, all body markings jet black at eclosion.....*C. californiensis*.

*All larval bodies became tinted by food in the gut; greenish in five species, golden brown in *C. mcdunnoughi*.

b. SECOND INSTAR LARVAE

In the second instar the definitive head patterns appear, while, in five species, the body traits of the first instar are retained. In *C. benjamini* all traces of the first instar pattern disappear. In *C. chelidonia* and *C. mcdunnoughi*, which share a wide dorsal stripe in the first instar, the

lower genae are parallel-lined, and longitudinal line 3, of the body, forms a series of oblique dashes through the SD1 setae to the L1 setae of the following segments. Reticulate genal patterns are found in the other four species. The separation of the six species into a group of two, and a group of four, is reinforced by additional differences in later instars.

- 1a. Head and body ground color pale yellow, markings bright brown; genal pattern definitely parallel-lined below; head vertex unmarked, inverted Vs of the front incomplete; body setae and bases black; six lateral longitudinal lines; body lines, five lateral patches, and ventral spots all brown.....
.....*C. mcdunnoughi*
- 1b. Head and body color white to gray, head markings black, body markings mostly gray or black.....2
- 2a. Genae entirely reticulate. On the body, the uppermost longitudinal line through the thorax D2 setae and the abdominal D1 and D2 setae; six lateral patches, or none.....3
- 2b. Genae markedly parallel-lined; on the body, the uppermost longitudinal line through the thorax D1 setae, and mesad from the abdominal D1 and D2 setae; seven lateral dark gray patches; head and body pale gray, dorsum darker than the sides, body contrastingly striped in gray and black
.....*C. chelidonia*
- 3a. Lateral patches lacking; body evenly, longitudinally, striped in white, the stripes parallel, separated by very narrow, dark, gray-stippled lines; middorsal line pale gray, setae and bases black, ventral spots black.....*C. benjamini*
- 3b. Lateral patches present, body pattern much as in the first instar4
- 4a. Heads and bodies, overall, obviously dark gray5
- 4b. Head and body very pale gray, the body dorsum with a pale, longitudinal stripe with gray midline, the line regularly interrupted; at either side, narrow, interrupted gray lines, the segments alternating with those of the middorsal line; three lateral, longitudinal, dark gray lines, the first through the dorsal setae, the third continuous through the SD1 setae; gray lateral patches on A1 to A6.....*C. californiensis*
- 5a. Five dark gray to black, heavy, lateral, longitudinal lines, the uppermost through the dorsal setae, line 3 continuous; head and body appearing dark gray overall from heavy markings; dark gray middorsal line bordered by narrow, broken, white lines, these laterally by narrow, broken, gray lines, the breaks of the two series alternating; dark gray lateral patches on A1 to A6.....*C. andromache*
- 5b. Three dark gray to black, heavy, longitudinal, upper lateral

lines, the first through the dorsal setae, line 3 an interrupted series of oblique dashes through the SD1 setae to the L1 setae of the following segments; head and body appearing dark gray from heavy pattern; gray middorsal line without bordering alternating gray and white dashes; dark gray lateral patches on A1 to A6 *C. johnsoniana*

c. FIFTH INSTAR LARVAE

In the fifth instar differentiation between the species reaches a maximum. The lower genae of *C. chelidonia* and *C. mcdunnoughi* retain a pattern of straight lines. In both, the pair of lines rimming the face are gray and free of orange coloring. In the third and fourth instars the ventral filaments develop tardily in both. The larvae confirm an alliance between the two species first observed by Brower (1937) in a study of their adult characters.

Of the four species with reticulate genae, all display a black facial rim with orange coloring between the two lines rimming the face. Two of the four, *C. californiensis* and *C. johnsoniana*, in the fourth and fifth instars develop a series of jet black bars on the dorsum caudad from the D2 setae, forming a distinctive convergent pattern, unlike *C. andromache* and *C. benjamini*. At the apex of the adfrontals is a sagittate patch in *californiensis* and *johnsoniana*. In the first instar their larvae, only, eclosed with shining, jet black heads, and jet black body markings. The A5 middorsal tubercle appears in the fourth instar. These characters, taken with adult wing characters that set them apart from *andromache* and *benjamini*, suggest a greater degree of alliance between them than with the other two species.

The interrelationships of *C. andromache* and *C. benjamini* await further knowledge. Three disjunct populations of *C. benjamini* exist, those of the desert slopes of the California coast ranges; a population in the eastern Mohave Desert in the Providence and New York Mountains; and the Arizona population from which *benjamini* was first described. The immature stages of the Pinyon Flat population are the only stages of the species presently known. These differ markedly from *C. andromache*. The *benjamini* adults from Pinyon Flat also differ markedly, both from *andromache*, and from Arizona *benjamini*. Comparative studies of the adults of the three *benjamini* populations, and of *andromache* are required, together with comparative studies of the larvae of all of these entities; additional examples of larvae of *andromache* and Pinyon Flat *benjamini* are needed as well.

The keys to the first and second instar larvae, whose characters are more stable, will probably stand as is. The construction of keys for *Catocala* larvae of later instars when based upon small samples of larvae offers more difficulties due to the greater variability in color that the larvae

of some species display. In constructing a key to the fifth instar larvae, the author has relied chiefly on traits that tend to remain constant during variation in color. This may make the key more serviceable.

The key has been prepared to fit into Crumb's key, it being necessary to modify two of his statements in order to incorporate into it the six species of this study. My key includes, from Crumb's key, only the statements that lead to the separation of the six species. Other statements must be followed in his key. Crumb's number sequences have been used, with letters *a* and *b* added, to clarify which of a pair of Crumb's choices is being used. The two modified statements are starred with asterisks, and the changed wording underlined. To accommodate the additional six taxa, Crumb's number sequence has been extended.

- 1a. With a middorsal hump, horn, or transverse ridge on abdominal segment 5. A fringe of fleshy filaments present laterally on the venter. Mandible with a free basal process bearing on an apical molar area (pl. 11, C.). Head often distinctly protuberant between setae P¹ and P²20
- 20b.37
- *37b. Skin without granules. Setigerous tubercle II at least somewhat elevated throughout on abdominal segments. Spiracles brown, or yellow38
- 38b. Middorsal prominence on abdominal segment 5 a transverse, low, rounded hump, usually with a short subconical projection medially and without a secondary horn or other prominence39
- 39a. Feed on oak40
- *40b. Head usually distinctly protuberant between setae P1 and P2, the face often with inverted black Vs with vertices at setae P1, and rimmed by a double line anterior to the ocelli, giving the front a strongly lined appearance, sides and tops of head not reticulate with red, *Arizona and California* species47
- 47a. The two lines rimming the face anterior to the ocelli lacking an orange color filling the space across the vertex and dorsad of ocellus I48
- 47b. The two lines rimming the face anterior to the ocelli with orange color between the lines on the vertex and laterally dorsad of ocellus I50
- 48a. Larvae with brown spiracles, body pale gray to blackish; lines of vertex and genae of head tending to be reticulate; the fifth abdominal segment median dorsal tubercle long, drooping posteriorly; larval ventral surface blue, median spots purple; thorax II with dark, dorsal patch.....*Arizona chelidonia*
- 48b. Larvae with yellow spiracles, the body white to pale brown;

- lines of the vertex and lower genae tending to be parallel; the fifth abdominal segment median dorsal tubercle short, erect, or reduced to a transverse swollen ridge; venter nearly, or quite white, or pale brown, median spots brown; no dorsal dark patch on thorax II49
- 49a. Larva nearly white, lineations much subdued; median tubercle of abdominal segment 5 reduced to a smooth transverse fold, the segment swollen; the venter white, median spots brown*mcDunnoughi*
- 49b. Larva pale gray to pale brown, prominently lined in dark gray, or black, or brown; median dorsal tubercle of abdominal segment 5 short, erect; venter whitish or pale brown, median spots dark brown edged in redCalifornia *chelidonia*
- 50a. Larvae with dark gray or black sagittate patch on the adfrontals; the dorsum of the body with a series of jet black bars or ashes convergent from the D2 setae towards the midline.....51
- 50b. Larvae lacking an inverted sagittate patch on the adfrontals; the body dorsum lacking a pattern of black bars or dashes convergent from the D2 setae.....52
- 51a. Head with black sagittate patch on the adfrontals; the larva almost white, a middorsal black line on a median, wider, dorsal, longitudinal, white stripe edged by a dark gray line laterally. Lateral longitudinal, gray and black lineations reduced; dark patches on the sides across the spiracles from T1 to A9, most prominent on A1 to A3.....*californiensis*
- 51b. Larva with a gray sagittate patch on the adfrontals; the larva very dark gray, with complex pattern of contrasting light and dark gray, or black, patches and lineations.....*johnsoniana*
- 52a. Head pale gray, face white, rear vertex dark gray, a black bar caudad of seta P2, orange rim absent from white area around seta P2; larva nearly white, the narrow, numerous, longitudinal gray lineations subdued; median tubercle of abdominal segment 5 on a prominent transverse ridge.....*benjamini*
- 52b. Head medium gray with heavy markings, appearing dark gray; the bar from the P2 seta caudad on the vertex narrow, sinuous, gray, the facial rim with continuous orange coloring; the larva very dark gray, the longitudinal lineations indistinct in general, heavy, gray and black stippling.....*andromache*

*statement reworded in part

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